

1       **METHOD FOR REMOTE MONITORING OF WATER TREATMENT SYSTEMS**

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3       CROSS REFERENCE TO RELATED APPLICATIONS

4           This Application is a continuation-in-part application of Application No. 10/392,112, filed  
5       March 19, 2003, which is a continuation-in-part of Application No. 10/055,225 filed October  
6       26, 2001 now U.S. Patent No. 6,560,543, which is a continuation in part of Application No.  
7       09/213,781 filed Dec. 17, 1998 now U.S. Pat. No. 6,332,180, the contents of which are  
8       incorporated herein by reference.

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10       FIELD OF THE INVENTION

11           This invention is related to the field of water treatment, and in particular, to a method of  
12       monitoring advanced separation and/or ion exchange processes by use of the world wide web  
13       allowing review of data collected and compiled asynchronously from a web server.

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15       BACKGROUND OF THE INVENTION

16           Potable water is essential, with quality and safety standards regulated by the Environmental  
17       Protection Agency (EPA) in accordance with the Public Water System Supervision program. The  
18       standards are enforced by local agencies. There are over 170,000 water districts in the United  
19       States which provide public drinking water to 90% of Americans.

20           The EPA has primary standards designed to protect public health against substances that

1 may be harmful to humans if consumed. EPA secondary standards ensure the aesthetic qualities of  
2 water such as taste, odor, or clarity. However, each water district remains responsible for  
3 monitoring the drinking water itself to ensure that it meets all drinking water standards. The  
4 treatment processes for the drinking water must be monitored as well.

5 In order to comply with the regulatory testing calendar, water districts are required to  
6 report a battery of analytical test results varying from quarterly to yearly, depending on the source  
7 of the water supply. Water systems must monitor their drinking water to ensure that it is safe for  
8 their customers. Monitoring schedules differ according to the type of contaminants that may be  
9 present in a given water supply. The quarterly tests are typically chlorine and turbidity, which can  
10 be accomplished with automatic analyzers. Water districts use electronic sensors to monitor the  
11 amount of storage, discharge pressure and flow from the systems on a daily basis. Other  
12 parameters which are not automatically sensed, but rather are determined by analytical tests, are  
13 reported to regulatory agencies on a periodic basis.

14 Municipal water may be obtained from any source, including seawater, all of which can be  
15 made potable by use of proper water treatment equipment. For instance, a reverse osmosis system  
16 is capable of lowering the total dissolved solids of sea water to drinking water levels. Despite the  
17 sophistication of pretreatment, improper operation can lead to fouled membranes. If fouling occurs  
18 but is found quickly, the membranes may be cleaned averting water contamination and associated  
19 water treatment repairs. However, if the fouling is not detected quickly, the water treatment system  
20 can be irreparably damaged and lead to human health concerns.

1           One of the problems with maintaining advanced processing equipment is a need for highly  
2           qualified individuals. Employment of a full time staff is costly and can be problematic since such  
3           monitoring is repetitive and highly qualified individuals can easily become bored. For this reason,  
4           all water treatment processes include a large assortment of strategically placed sensors that are  
5           typically incorporated into a computer system capable of comparing the sensor values against a  
6           pre-set quality level. However, if the operator does not recognize a particular alarm condition, the  
7           elaborate array of monitoring equipment is useless.

8           Municipal water treatment plants are ultimately the responsibility of elected officials. Yet  
9           these officials rarely have the technical training or time to allow them to directly access the  
10          performance parameters of the systems for which they are responsible. The present invention  
11          could easily be used to provide a readily understandable presentation of the current performance  
12          of a municipal water treatment system which was fully accessible by the elected officials as well as  
13          plant operators, at any time via the Internet, but which provided no access to the control system of  
14          the water treatment plant. In addition, in this application of the technology, the same presentation  
15          of the system performance could be made accessible to the public at large, allowing interested  
16          members of the public to monitor the operation of their own drinking water plants as desired.

17          Thus, what is lacking in the art, is a means for monitoring water treatment processes in a  
18          cost effective manner by highly trained personnel providing regulatory reporting with a real time  
19          analysis that can be simultaneously viewed and verified at any time by multiple parties, from any  
20          location having access to the Internet, but which provided no access to the control system of the

1 water treatment plant.

2 SUMMARY OF THE INVENTION

3 The instant invention is a method of monitoring water treatment systems, particularly those  
4 subject to regulatory reporting such as potable water treatment systems. The method includes the  
5 collection of data which are manipulated to generate preconfigured performance, maintenance,  
6 quality assurance, quality control, regulatory performance graphing, historical trends, and  
7 regulatory reports. The raw data is collected from sensor assemblies located at an equipment site  
8 which are networked to a server computer. The raw data may be transferred to the server  
9 computer in real time. The data received at the server computer can be used for the generation of  
10 reports also accessible by Internet connection. The reports, graphs and information can be viewed  
11 online or downloaded by use of a web browser. Regulatory reports can be forwarded  
12 automatically to the regulatory agency via electronic transmission means with the added benefit of  
13 receiving reports generated directly from the sensor input thereby eliminated the possibility of  
14 human error or tampering. The method allows a single location to monitor countless customers  
15 with each customer capable of reviewing information relevant to their equipment, all information is  
16 kept confidential by use of appropriate account names, protocols and passwords.

17 Thus, a primary objective of the instant invention is to provide a method of monitoring  
18 water treatment systems by compiling information from one or more sensor assemblies which are  
19 in direct communication with a server computer to generate operational information in near real  
20 time, if desired, which can be obtained from any location having access to the Internet. The

1 compiled information can be placed into the required format required by regulatory agencies.

2 Another objective of the instant invention is to provide a system that operates independent  
3 of the water treatment system wherein no feedback is possible to any monitoring or control system  
4 and to transfer such information by a local Internet provider or other internet connection to a  
5 consolidating Internet address.

6 Yet another objective of the instant invention is to provide an Internet report system that  
7 can be viewed online or offline providing alarms by the use of current and historical records.

8 Still another objective of the instant invention is to provide automatic real-time transmission  
9 of sensor data, data to graph conversion, data to statistical report conversation, compliance  
10 calendars, e-mail notification of compliance and the ability to automatically file data and reports  
11 with the regulatory agency.

12 Yet another objective of the instant invention is to provide scheduled and predicted  
13 maintenance reports by the use of the current and historical records; providing emergency  
14 notification of failures, shutdowns, critical parameters, membrane damage and the like by the use  
15 of electronic mail, pager, and/or human voice calling.

16 Another objective of the instant invention is to enable regulatory reporting without the need  
17 for human interface thereby negating human error or tampering.

18 Still another objective of the instant invention is to provide a method of regulatory reporting  
19 which is independent and/or complimentary of the existing monitoring system.

20 Other objectives and advantages of this invention will become apparent from the following

1 description taken in conjunction with the accompanying drawings wherein are set forth, by way of  
2 illustration and example, certain embodiments of this invention. The drawings constitute a part of  
3 this specification and include exemplary embodiments of the present invention and illustrate various  
4 objects and features thereof.

1     BRIEF DESCRIPTION OF THE FIGURES

2     FIG. 1 illustrates an exemplary network configuration of the system of the instant invention.

3     FIG. 2 is a pictorial representation of the various modules that make up the instant invention.

4     FIG. 3 is a flow diagram of the data analysis and report generator of the software.

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1     DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

2             Although the invention has been described in terms of a specific embodiment, it will be  
3     readily apparent to those skilled in this art that various modifications, rearrangements and  
4     substitutions can be made without departing from the spirit of the invention. The scope of the  
5     invention is defined by the claims appended hereto.

6             The instant invention is a monitoring system that incorporates the use of the Internet for  
7     providing a remote location for assimilation and dissemination of configured reports regarding  
8     water treatment systems primarily for the purpose of preparing and submitting regulatory reports  
9     required for operation of certain water treatment systems. Data is first collected on site at a water  
10    treatment facility by the use of at least one sensor assembly. Each sensor assembly includes a  
11    sensor and a communications interface, which interface may be formed integral therewith. One or  
12    more sensor assemblies and on-line analytical devices are utilized for transmitting raw data  
13    collected from numerous locations on a water treatment system.

14            In a preferred embodiment, the sensors are micro-sensors that incorporate chemically  
15    selective sensors and physical measurement devices on a single chip of silicon or other functional  
16    material that can chemically profile a sample as small as a drop. In a preferred embodiment the  
17    sensors include a communications interface effective for real time data transmission, such as a  
18    Lonworks® network variable interface. Suitable sensors would include the Six-CENSE <sup>T.M.</sup> and  
19    CT-CENSE <sup>T.M.</sup> manufactured by Dascore, Inc., as well as the multi-sensor devices manufactured  
20    by Sensicore, Inc. These sensors can measure chlorine, heavy metals, and various other

1 constituents by concentrating the analyte through a small membrane exposed to the stream being  
2 monitored. Electric current (amperometric) or voltage readings are then converted to a value by  
3 the control electronics within the device. Critical water parameters to be measured include, but  
4 are not limited to, free chlorine and monochloramine, dissolved oxygen, pH, conductivity,  
5 oxidation-reduction potential, temperature, color and turbidity.

6 Fig. 1 pictorially illustrates an exemplary arrangement in which a plurality of discrete water  
7 treatment systems, represented in the example as FACILITY A and FACILITY B, are  
8 networked to an Internet Server Computer 20 located off-site by use of local Internet access.  
9 Each facility includes at least one sensor assembly inclusive of a sensor device and a  
10 communications interface. In the illustrated example, FACILITY A includes Sensors  $A_{1-n}$  which  
11 are each in communication with Internet Server Computer 20. With respect to FACILITY B, an  
12 alternative arrangement is illustrated in which the Sensors  $B_{1-n}$  are networked in a parallel  
13 arrangement to both Internet Server Computer 20 and a local computer 15 located within  
14 FACILITY B.

15 Raw data is continuously transmitted from the sensors to the Internet Server Computer 20.  
16 Some or all the raw data relating to the critical water parameters being monitored by a sensor can  
17 be transmitted in real time. The Internet server computer 20 includes a data storage means  
18 whereby historical data may be maintained. The Internet server computer 20 has a software  
19 application running thereon which can be accessed through a Web site from a remote client  
20 computer 21 via a Web browser. In an alternative embodiment, proprietary software can be

1 resident on the remote client computer 21 which interfaces with the Web site on Internet Server  
2 Computer 20.

3 Fig. 2 graphically illustrates the flow of data. System operation is monitored in near real  
4 time by accessing an Internet web site 21 specifically set up for a particular customer or self  
5 configured by the customer. Data from the water or waste water treatment plant is collected on the  
6 Internet server computer 20 and stored in the database computer 23, which may be one and the  
7 same as the Internet server computer or a separate computer networked to the Internet server  
8 computer 20. As will be readily appreciated by those skilled in the art, the number and location of  
9 the Internet server computer(s) 20 and the database 23 may be varied to suit the network traffic or  
10 demands of a particular customer. The data collected on the Internet server computer 20 is also  
11 manipulated by the Internet server computer 20 wherein operating parameters are displayed  
12 graphically in a tabular format which may be color coded to provide an indication of normal  
13 operation, warning status or alarm conditions. The information from the sensors are used for  
14 determining critical information for the proper evaluation of the water treatment system which is  
15 normalized and graphically displayed for performance evaluation, preventative maintenance,  
16 scheduling, or for trouble shooting.

17 When the customer accesses the web site through a user request 25 the customer's  
18 credentials are compared 24 to the credentials stored in the database. If authenticated, the  
19 customer may then access near real time or historical performance data which 26 can be displayed  
20 or plotted and presented also in geographical or tabular form reports 27 for selected periods. The

1 requested reports and displays are then placed into the client's web pages for display on the  
2 client's browser 22. This provides for not only a historical analysis of system performance, but  
3 also a record of prior performance for quality control or regulatory recording purposes.

4 When data arrives at the Internet server computer 20, secondary programs 29 can be  
5 executed against this data to calculate any manner of statistical inferences or derived data. These  
6 secondary programs can directly send email or text pages or voice messages or other alerts to a  
7 variety of personal communications equipment such as cell phones, pagers, Blackberrys and Palm  
8 devices. In this manner, the software is designed to continuously scan sensor input and compare  
9 the current value with alarm set points in a pre-determined report. These set points may be  
10 different than actual locally set alarm points. For example, management may wish to see all  
11 instances where conditions were close to an alarm or trigger point and such conditions may be  
12 summarized in exception reports. The device further has the ability to notify authorized users by e-  
13 mail or use of a pager when process conditions meet or exceed, or appear likely to exceed,  
14 normal alarm conditions. This provides a layer of redundancy in system operation, and allows  
15 non- technical and management personnel to be notified promptly in the event of non standard  
16 operations. The local facility computer 15 shown in Fig. 1 can also include a software program  
17 operable to perform the steps of reading, querying, and storing data received from the sensor  
18 assemblies and periodically transmitting this data to the Internet server computer.

19 The system will automatically prepare the documentation required to meet the regulatory  
20 requirements. The documentation can be printed out and mailed or transmitted by facsimile to the

1 regulatory agency. Ideally the regulatory report document is sent directly to the regulatory agency  
2 via electronic transmission methods such as .ftp (file transfer protocol) or e-mail (smtp) thereby  
3 eliminating the opportunity for human error and/or manipulation. The device can easily be adapted  
4 to send data directly to the regulatory database in the format required by the regulatory database.  
5 The customer is capable of accessing data related to his processing equipment including all data,  
6 information and reports by use of any computer having Internet access capability. This eliminates  
7 the need for specialized equipment and allows a manager operating at his desk to access the data  
8 from any location whether it be the office, home, or on the road without the use of specialized  
9 computer systems. The software program continually updates the reports for the customer or a  
10 customer may view the reports or download them from the web site.

11 In the preferred embodiment, the reports are configured to particular regulatory  
12 requirements when a service agreement is established. For instance, the process system operations  
13 would contain the information necessary to monitor, maintain, supervise and trouble shoot process  
14 plant system performance. In this manner, non-limiting examples of the typical information and  
15 parameters process block would include, if applicable, flow rates, pressures, differential pressures,  
16 permeate quality, pH, alarm conditions, tank levels, and a graphical presentation of applicable  
17 process performance parameters and trends. A regulatory report would contain the information  
18 necessary to enable a regulatory agency to determine operational parameters including quality and  
19 quantity of the treated water to confirm compliance with specifications and standards. Information  
20 in this report would typically include treated water production rate (flow), treated water

1 consumption rate (flow), treated water storage volume, reserve capacity (at current production  
2 and consumption rates), final treated water quality, reports and archive data for regulatory  
3 compliance and/or QA/QC documentation.

4 Calculated/estimated overall plant efficiency may be provided as a percent of theoretical  
5 efficiency. Efficiency could be based on the theoretical minimum water, power, and chemical  
6 consumption versus actual consumption calculated.

7 Each sensor assembly includes a communications interface which networks the sensor to  
8 the Internet server computer 20 to continuously transfer data to the computer in real time. The  
9 connection can incorporate a dedicated network connection in addition to a wireless connection.  
10 At the Internet server computer 20, the high level program also utilizes a series of configuration  
11 parameters, which may be stored in "\*.ini" type files or a database to establish the path to where  
12 the raw data exists. This data is the data which needs to be analyzed, formatted and presented.  
13 The configuration file also contains the output path names to the various directories used by each  
14 client when they access their data via a web browser.

15 Each sensor assembly includes a communications interface which networks the sensor to  
16 the Internet server computer 20 to continuously transfer data to the computer in near real time.  
17 The connection can incorporate a dedicated network connection in addition to a wireless  
18 connection. At the Internet server computer 20, the high level executive program also utilizes a  
19 series of configuration parameters, which may be stored in "\*.ini" type files or in a database to  
20 establish the paths to where the raw data exists in the sensors and where the received data is to be

1 stored. As will be appreciated by those skilled in the art, there are many different, but effective  
2 methods, for establishing the location of the data and decoding the sent data into the appropriate  
3 rows or tables within a database. This data is the data which needs to be analyzed, formatted and  
4 presented. The configuration file also contains the output path names to the various directories  
5 used by each client when they access their data via a web browser.

6 As shown in Fig. 3, data arrives from a sensor assembly and is subsequently processed by  
7 sub-programs on the Internet server computer 20. As can be easily appreciated, the Internet  
8 server computer 20 may be in actuality a plurality of separate computers or processors designed  
9 to spread the processing load as needed. The ID of the sensor assembly is validated and if  
10 validated the data is stored in the database. Appropriate unit transformations or scaling  
11 parameters may be added from information retrieved in a configuration file or stored in the  
12 database. If the sensor ID is not validated, a message is written to a log file which may also be part  
13 of the database or a separate file. An invalid sensor ID could for example occur if a customer  
14 changed or added a sensor assembly or the customer's account was inactivated.

15 Any statistical or computational or normalization programs can run at this time to establish  
16 alarm conditions or derived data. For example in water treatment it is desirable to know the  
17 product of the chlorine concentration and the time it is in contact with the chlorine, known as the  
18 CT product, before entering a distribution system or in the case of secondary treatment plant the  
19 waterway. This data needs to be calculated, typically from the value provided by the chlorine  
20 sensor assembly and from the level information in the contact tank. If the CT product is too low,

1 an alarm or alert may be generated from the calculated data.

2 As a further example using a reverse osmosis system as the process being monitored, the  
3 feed pressure is critical in determining the future and current performance of the system in  
4 reference to its performance when new. Furthermore, for reverse osmosis membranes, changes  
5 in pressure are related to age, production rate, and temperature. Thus a change in flow rate may  
6 or may not indicate that the overall system's performance has changed when normalized and  
7 compared to its performance when new or recently cleaned. Prior to this invention, the complex  
8 mathematics for these conversions required some manual intervention on the part of the operator  
9 to compute the normalized conditions. The instant invention does this automatically  
10 and reports normalized data to the output.

11 Of course, many more process parameters are monitored, normalized, and analyzed by  
12 the computer software of this invention. The results of these analyses are then utilized in the  
13 following manner:

14 Raw performance data compared to normalized or corrected data is plotted in simple,  
15 easy to understand graphs which are published as html or in pdf, jpeg, gif, or other format readily  
16 usable by a web browser. The performance is compared to predicted normalized performance  
17 and if the differential exceeds preset limits (found in the configuration information) selected  
18 individuals are automatically sent E-mail or in more extreme cases a pager or fax (paper) alert.  
19 Process and regulatory reports are prepared from the data and published in a variety of formats  
20 for access by a web browser, including Excel spreadsheets, pdf files, text documents, and html

1 tables. Historical data is regularly updated by the data coming into the system and new graphs and  
2 reports are either produced on demand from the user via a browser request or prepared and  
3 stored on the web pages as noted. Scheduled maintenance requirements are reviewed by the  
4 software and if needed within a preset time--usually within one week, or E-mail notification is sent  
5 to the designated individual(s).

6 In either case, the output is sent to the designated web directories on a web server  
7 attached to the Internet. These directories are appropriately protected for access only by  
8 authorized individuals. It may be appreciated that the physical location of the Main Data  
9 Computer, the ftp server, and the web server may be at the same location or remote from each  
10 other. In addition mirror sites can be maintained as necessary to provide reliable service. The main  
11 computer may be either a stand alone unit or can serve as the Internet web server in itself in  
12 addition to performing the actual computations. No particular operating system is preferred for the  
13 web server and either Microsoft Windows or UNIX may be utilized depending on convenience,  
14 reliability, and cost issues.

15 It is to be understood that while I have illustrated and described certain forms of my  
16 invention, it is not to be limited to the specific forms or arrangement of parts herein described and  
17 shown. It will be apparent to those skilled in the art that various changes may be made without  
18 departing from the scope of the invention and the invention is not to be considered limited to what  
19 is shown in the drawings and described in the specification.

20